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H. HOELLJES.

METHOD OF OPERATING GAS ENGINES.

No. 408,483. Patented Aug. 6, 1889.

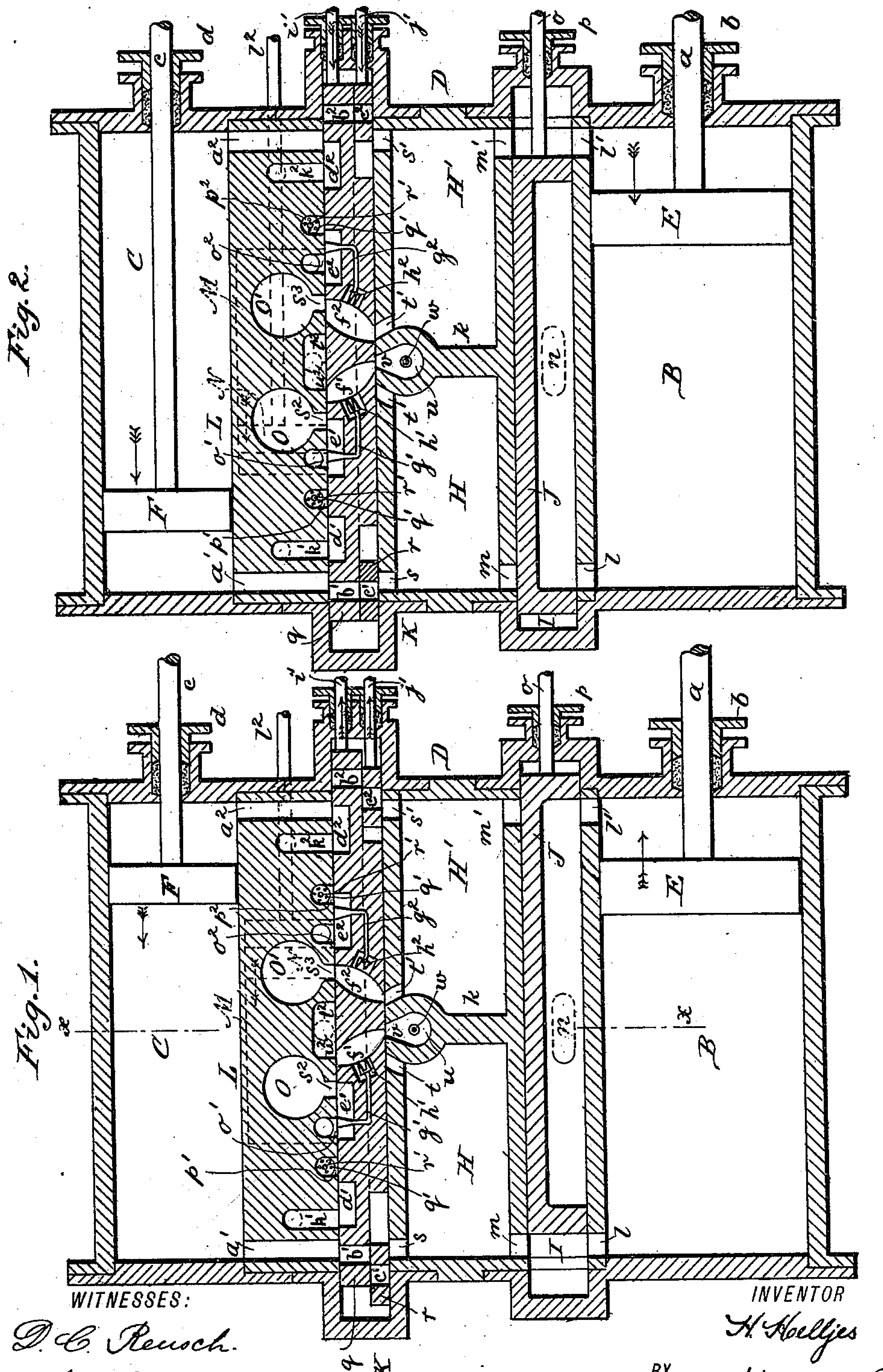

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Fig. 4.

Fig. 3.

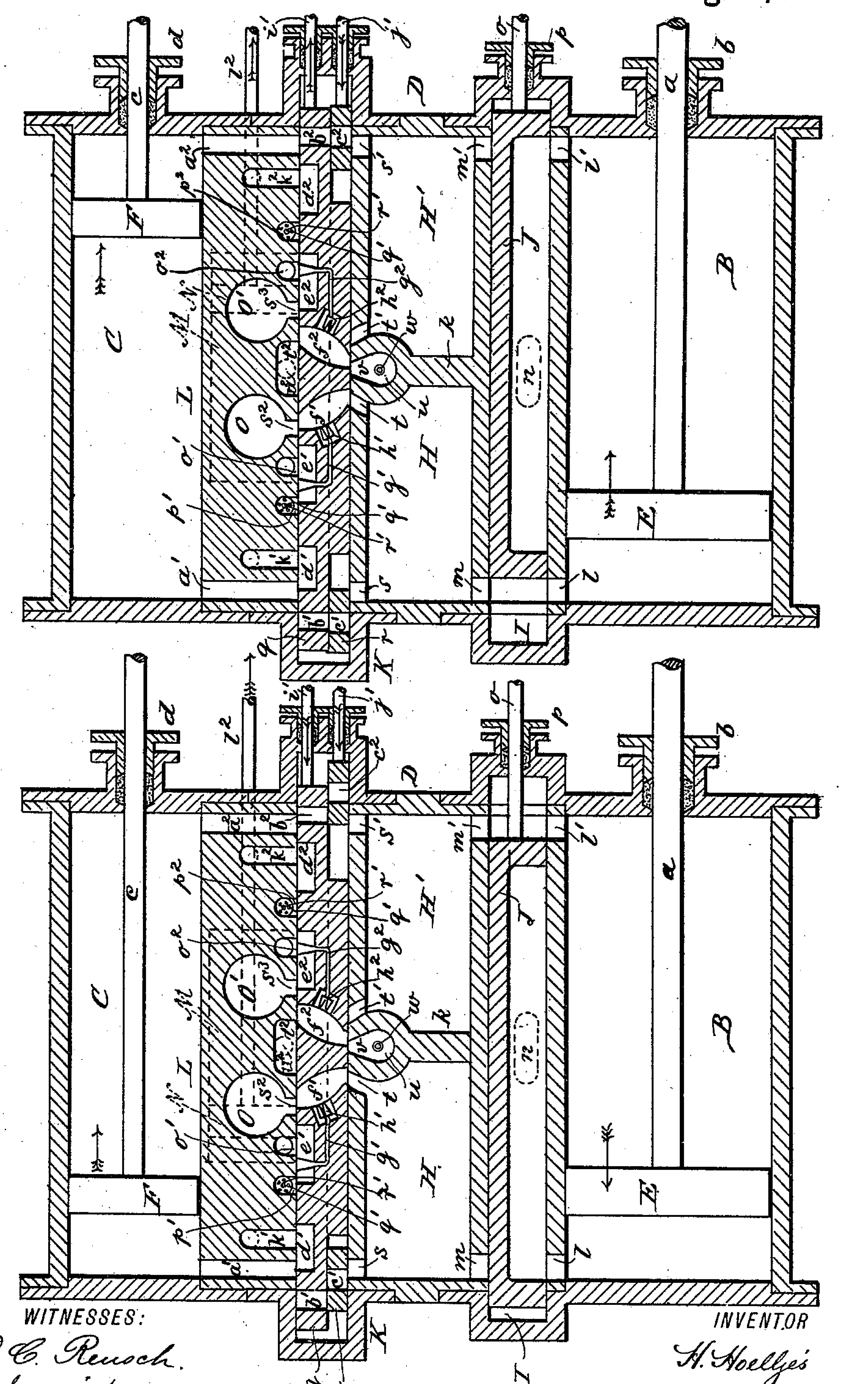

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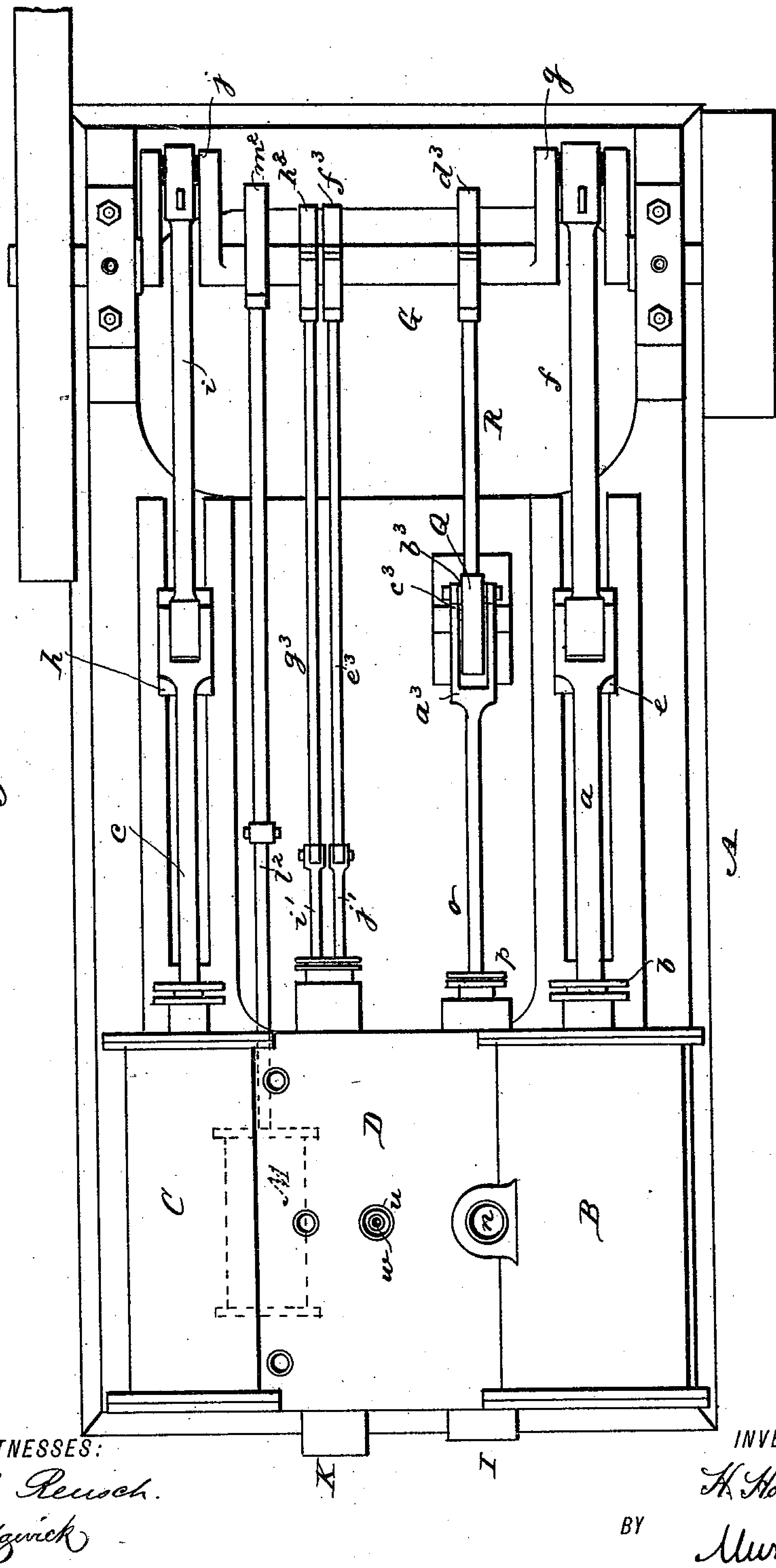
Fig. 5.



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METHOD OF OPERATING GAS ENGINES.

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Fig. 6.

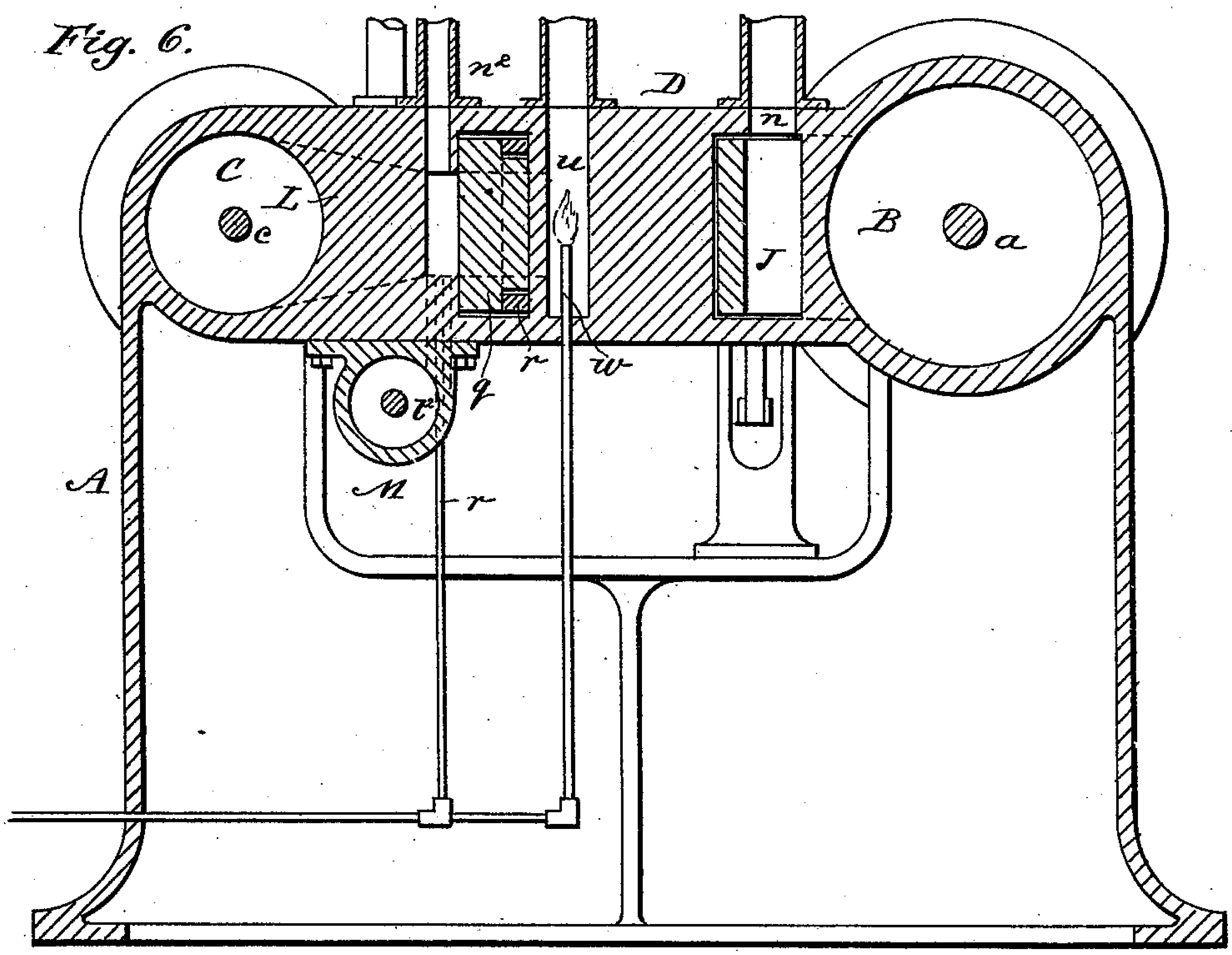

Fig. 7.

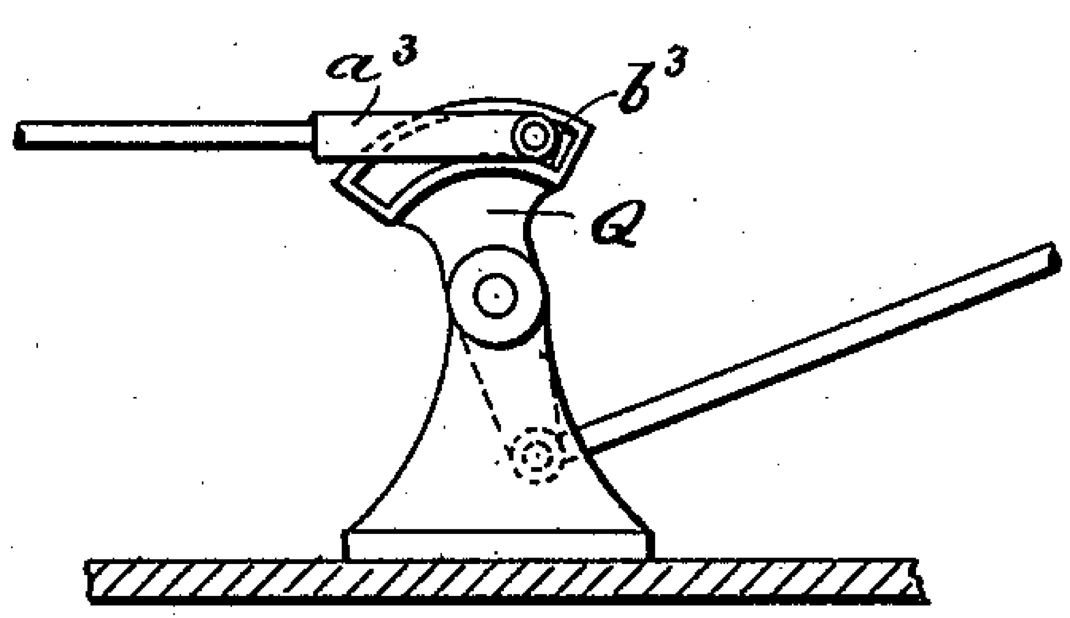

Fig. 10.

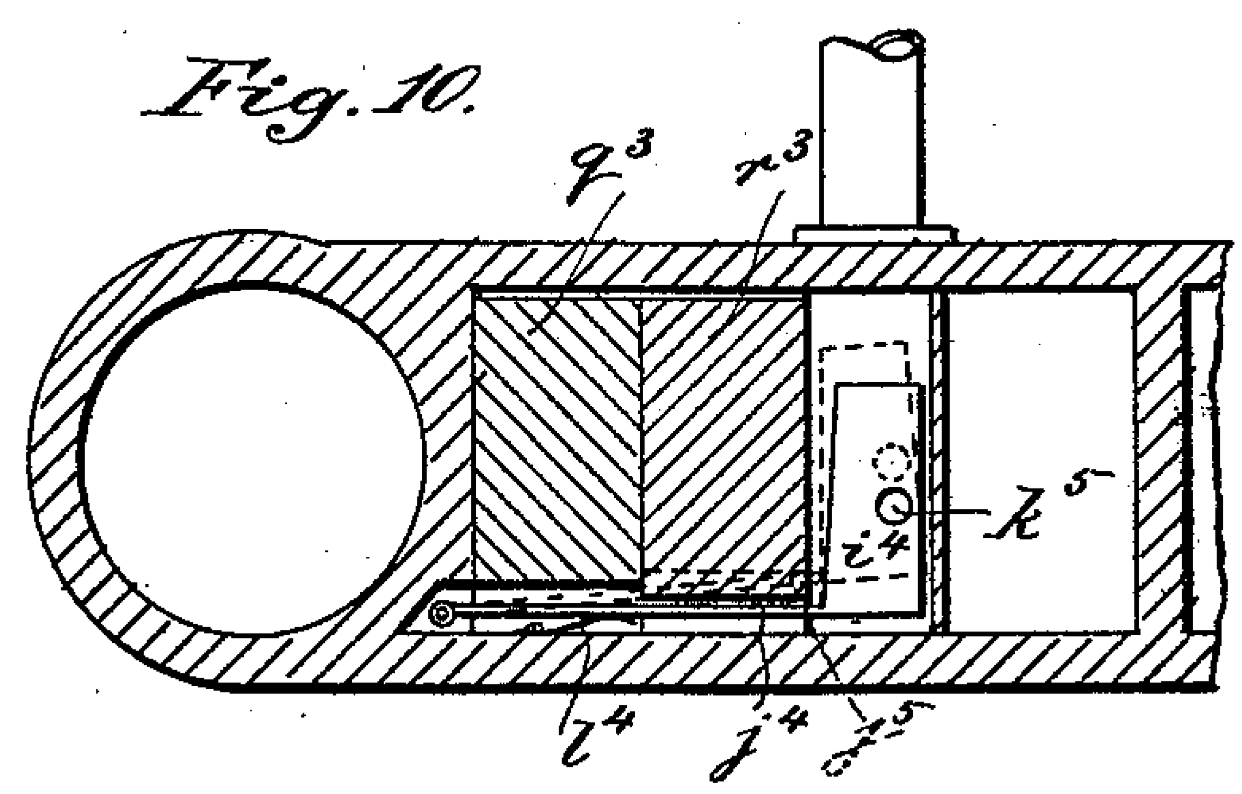

Fig. 11.

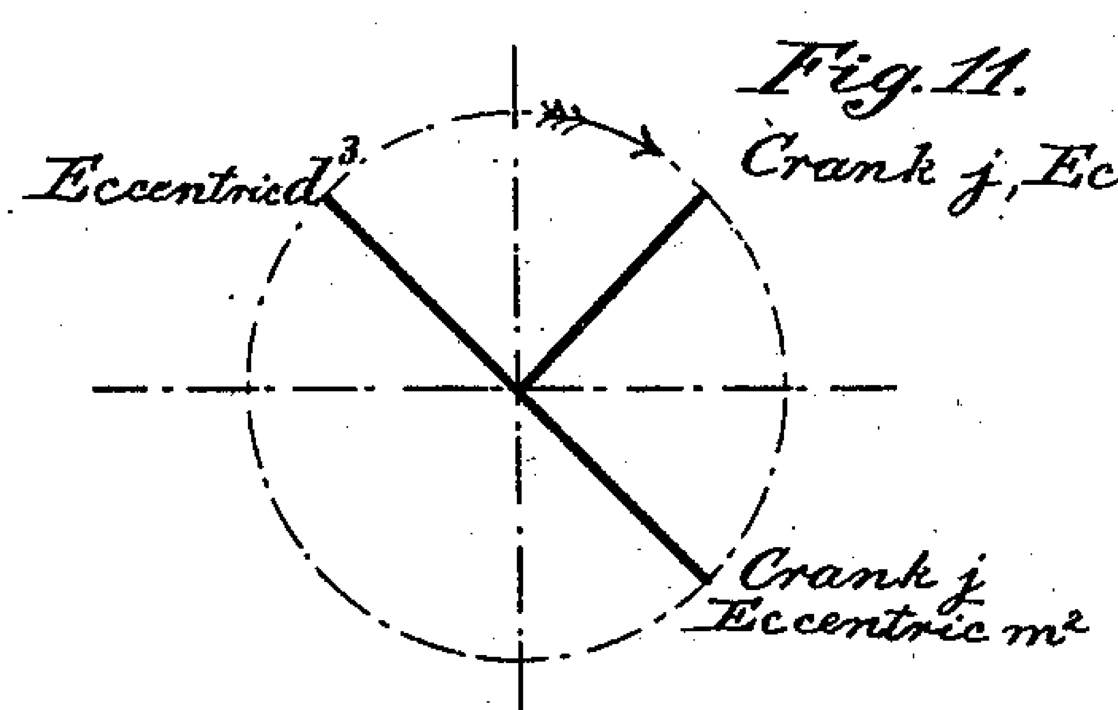

Fig. 12.

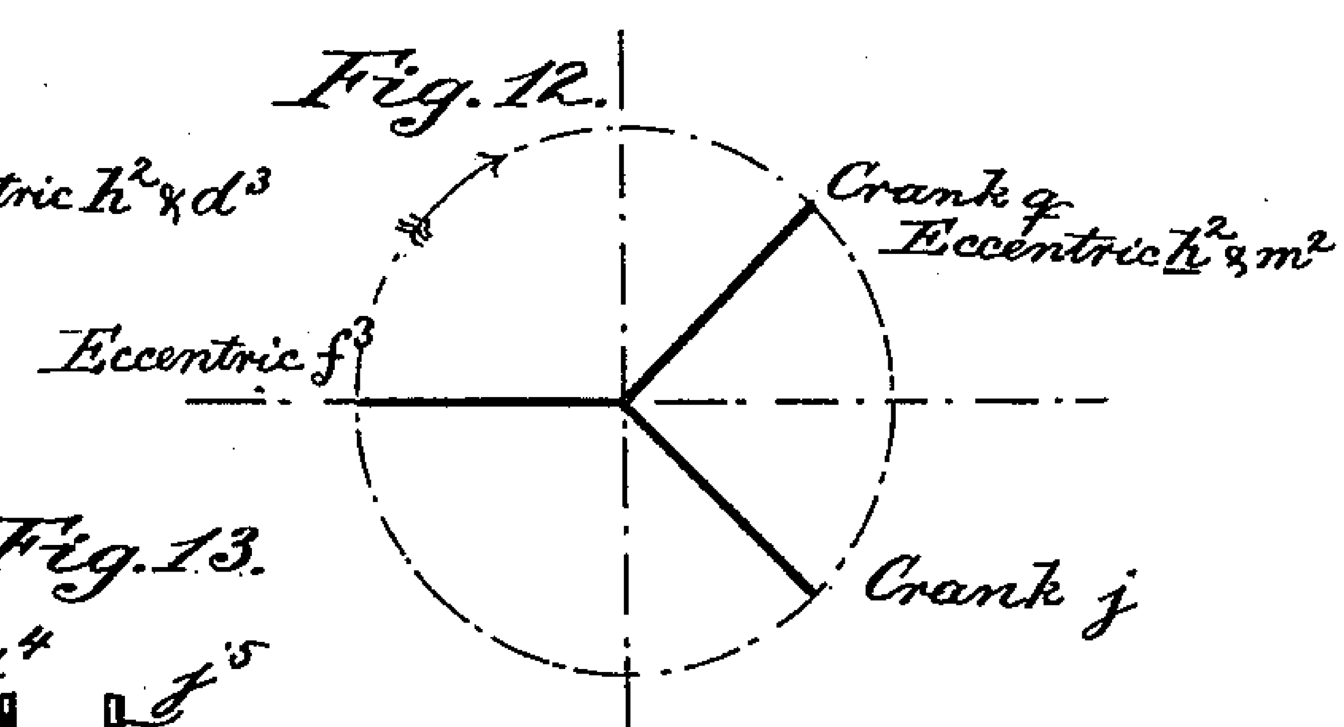

Fig. 13.

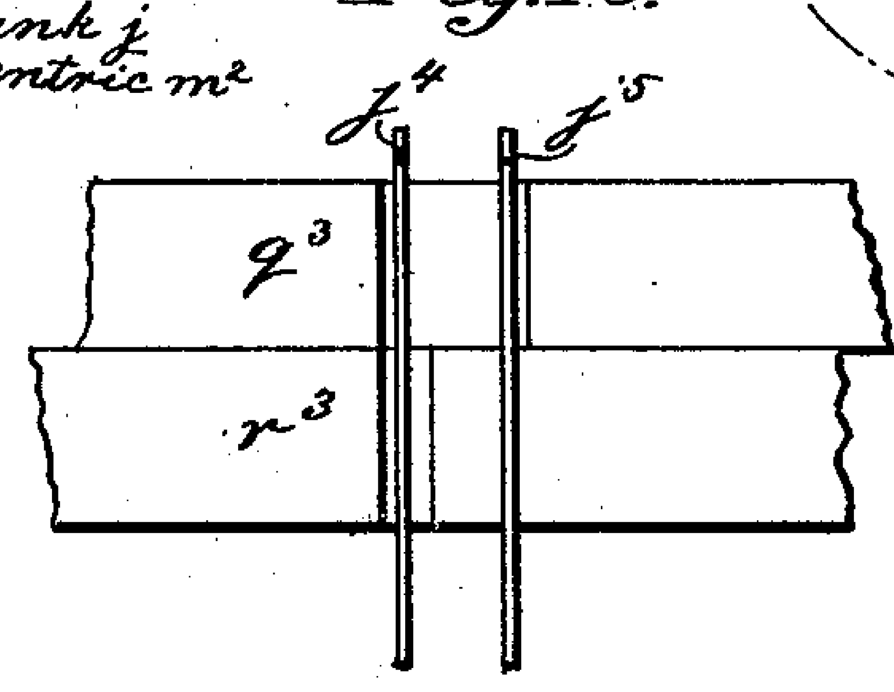

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Fig. 9.

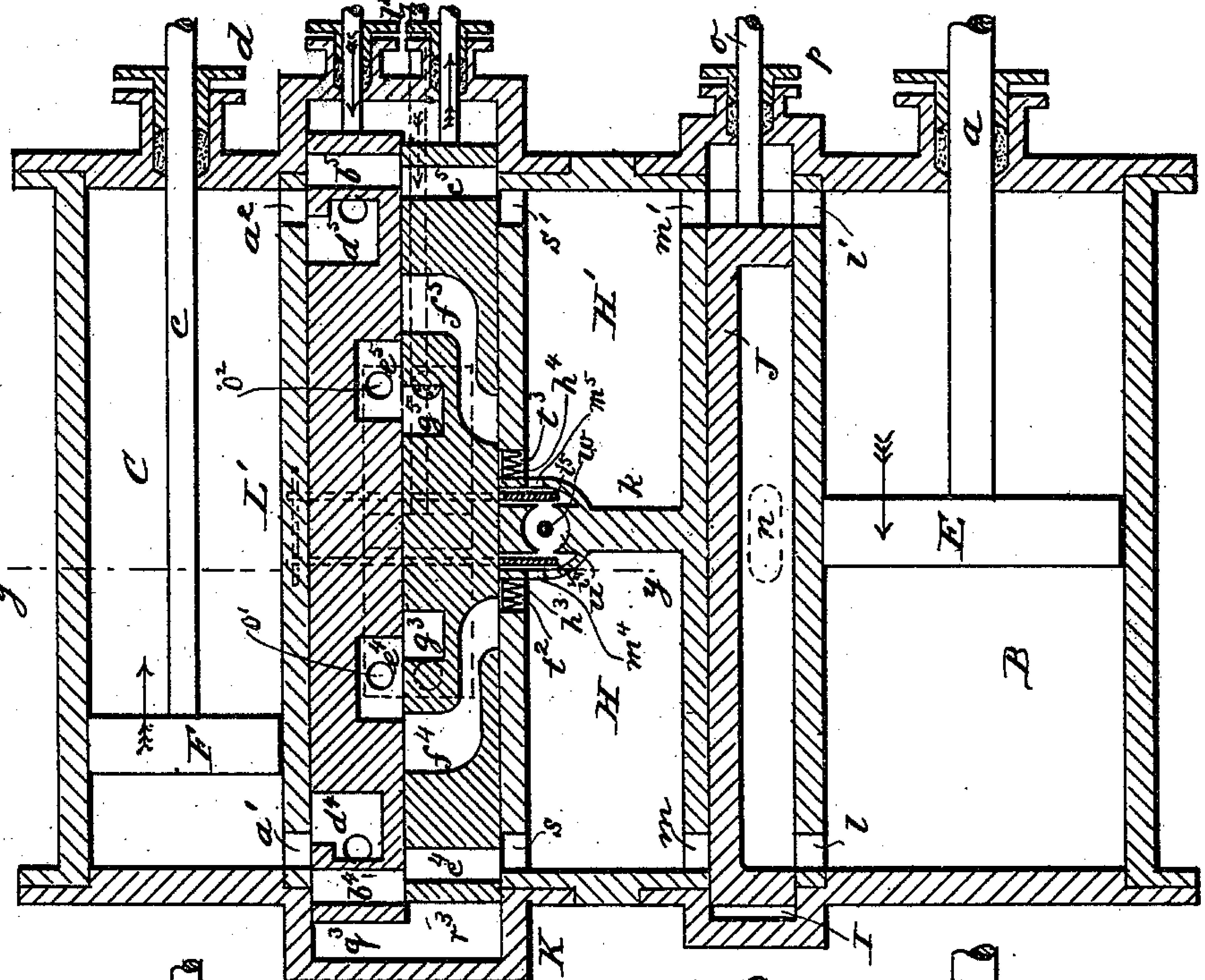

Fig. 8.

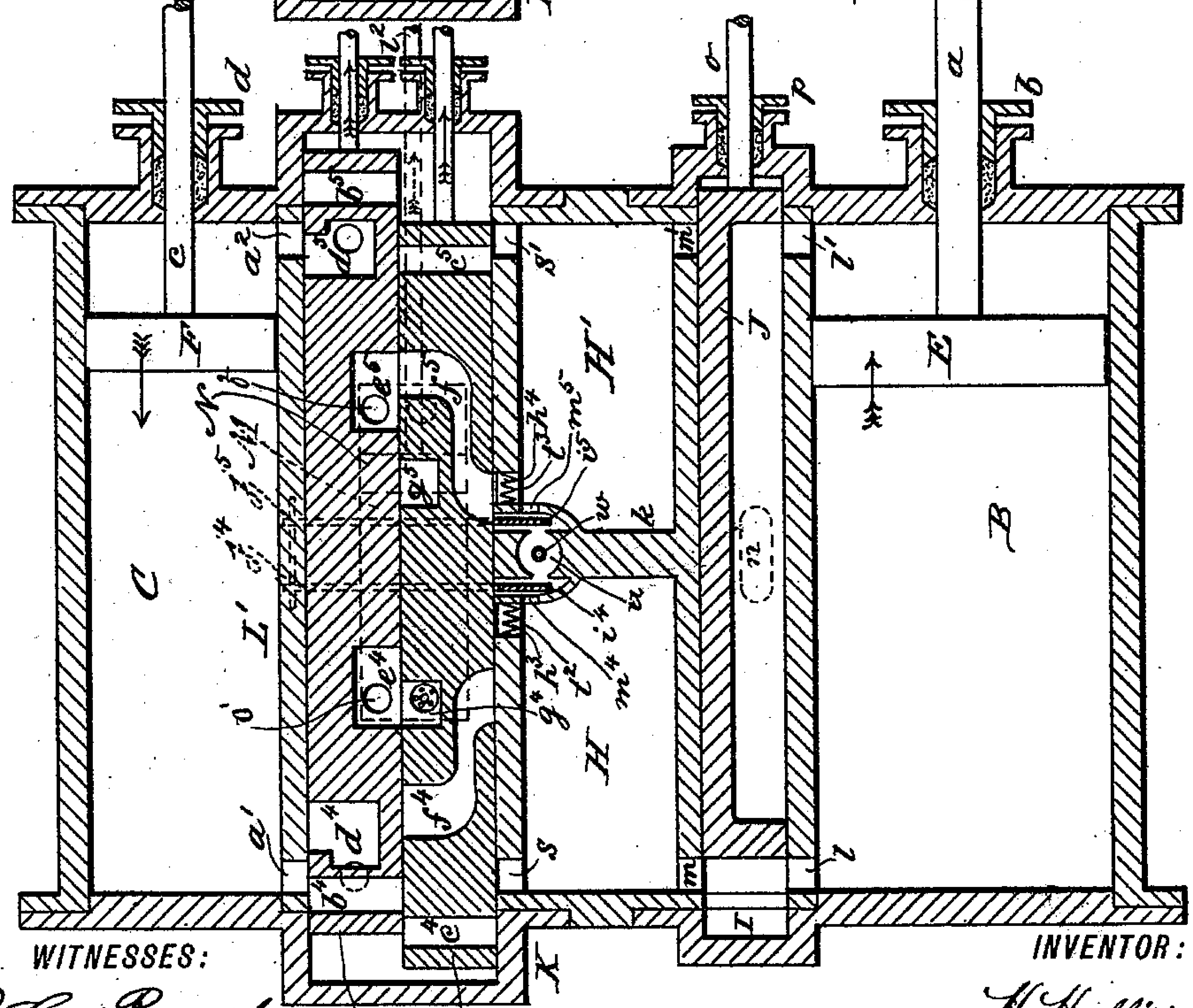

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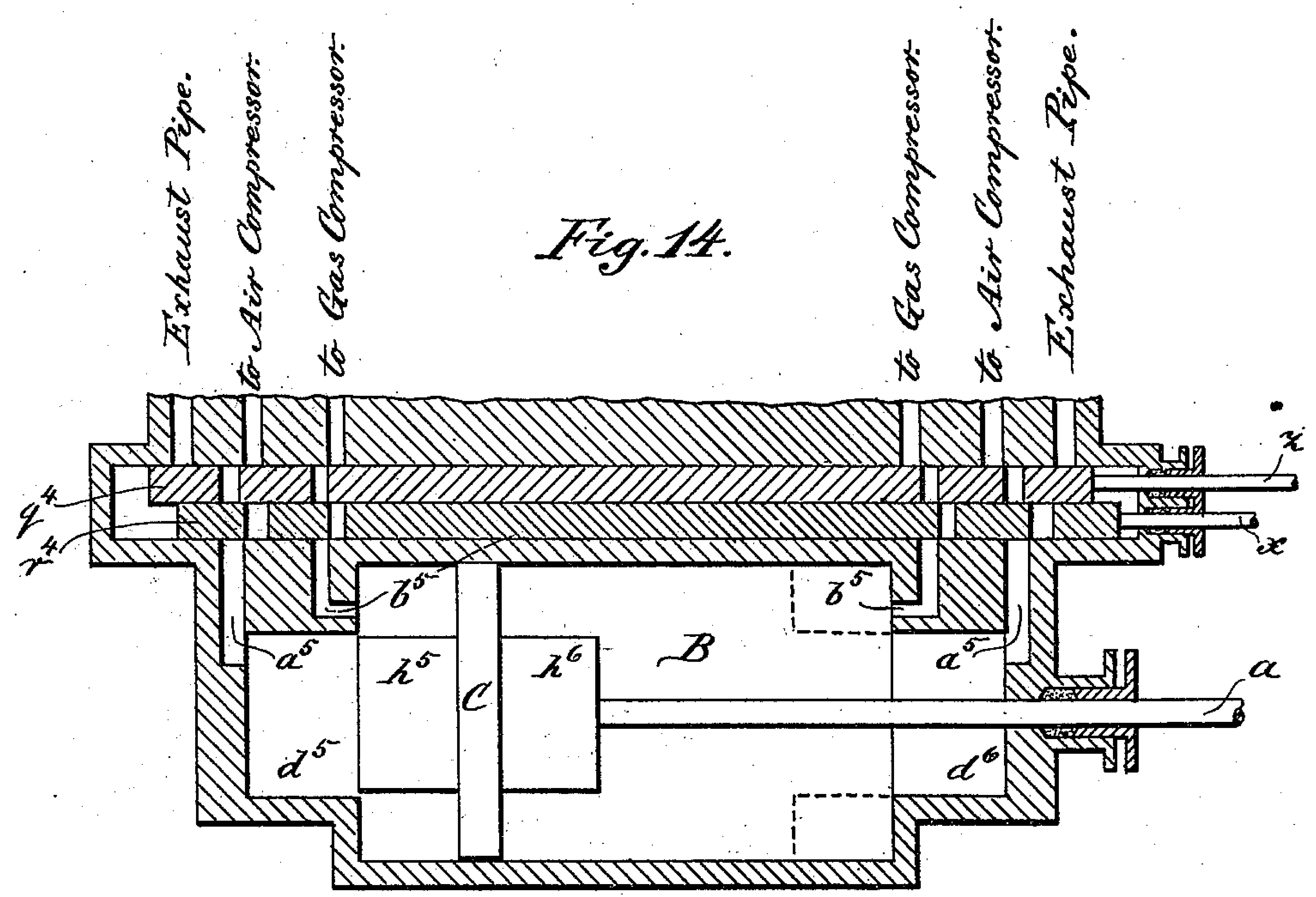
Fig. 14.



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UNITED STATES PATENT OFFICE.

HENRY HOELLJES, OF NEW YORK, N. Y.

METHOD OF OPERATING GAS-ENGINES.

SPECIFICATION forming part of Letters Patent No. 408,483, dated August 6, 1889.

Application filed March 6, 1889. Serial No. 302,137. (No model.)

To all whom it may concern:

Be it known that I, HENRY HOELLJES, of the city, county, and State of New York, have invented a new and Improved Method of Operating Gas-Engines, of which the following is a specification, reference being had to the annexed drawings, forming a part thereof, in which—

Figures 1, 2, 3, and 4 are horizontal sections of the cylinders and valves of my improved gas-engine, type A, showing the parts in the different positions required to perform one cycle of operations. Fig. 5 is a plan view. Fig. 6 is a vertical transverse section taken on line *x x* in Fig. 1. Fig. 7 is a detail view of the lever for operating the slide-valve controlling the supply to and exhaust from the power-cylinder. Figs. 8 and 9 are horizontal sections of the cylinders and valves of type B of my improved engine, showing the valves and pistons in different positions. Fig. 10 is a transverse section taken on line *y y* in Fig. 9. Figs. 11 and 12 are diagrams illustrating the relation of the power-cranks and the valve-operating eccentrics. Fig. 13 is an inverted plan view of the slide-valves of type B, (shown in Figs. 8 and 9,) showing the devices for operating the igniting-valves; and Fig. 14 is a longitudinal section of a cylinder and valve-chest of a different form of gas-engine, which I have designated as type C.

Similar letters of reference indicate corresponding parts in all the views.

In gas-engines as commonly constructed either an explosive mixture of compressed gas and air is introduced into the cylinder, where it is ignited and exploded to propel the piston, or separate charges—one of neutral gases, the other of an explosive mixture—are introduced into the cylinder, the neutral gas being for the purpose of cooling the exploding gases, thus reducing the temperature in the engine. As in the latter mode of operating such engines no provisions are made to maintain the separation of the neutral gases and the explosive mixture until the moment of explosion, the neutral gases very rapidly intermingle with the explosive mixture, so that instead of maintaining the heterogeneous mixture a rarefied homogeneous mixture is formed. For this reason it is impossible to introduce large proportions of neutral gases on account of diluting the mixture, so as to render it incapable of ignition.

In both of the types of engines to which I have referred a very high temperature is reached in the power-cylinder, which is objectionable for two reasons: first, a large amount of the heat of the combustion of the gases is rendered latent, as the specific heat of the gases increases with the temperature, and, furthermore, at very high temperatures a dissociation of the products of combustion takes place, which results in the absorption of considerable heat, and, second, they necessitate the absorption of the excess of heat by means of water-jackets or analogous devices. The use of water-jackets in gas-engines is objectionable in many cases on account of the difficulty and expense in securing the required amount of water for cooling the cylinders, and also on account of the enormous loss of heat which is carried away by the water.

The object of my invention is to provide means which will admit of using lower temperatures in gas-engines, thereby avoiding the dissociation of the products of combustion, to reduce the specific heat of the gases, to diminish the loss of heat through the cylinder-walls, and also to avoid the use of water-jackets.

My invention consists in the employment of compressed air or any other suitable gas or vapor kept separate from the explosive mixture until the combustion takes place, the compressed air being intended to absorb the heat produced by the combustion. By the absorption of the heat in this manner the pressure of the compressed air increases, and the difference between the original pressure and the pressure as augmented by heat is utilized by causing the heated compressed air to propel a piston.

To carry out my invention I compress the air, gas, or vapor into the power-cylinder or an intermediate chamber connected with the power-cylinder by suitable valves. Into the air so compressed I introduce the explosive mixture in an ignited state, thereby raising the temperature of the compressed air without unduly heating the walls of the chamber or cylinder. This I effect in either of two different ways, the first of which is to compress the explosive mixture into an intermediate chamber adjoining the compressed-air chamber and to explode the mixture when the two chambers are thrown into communication by the opening of suitable valves, said valves being opened automatically by the explosion of the charge or moved by connection with some moving part of the engine. The second is to cause the compressed explosive mixture to flow through gas-burners, wire-gauze, or tubes with small apertures into the compressed-air chambers, and igniting it when it enters said chamber, the gas-burners, wire-gauze, or tubes being used to prevent the flame from running back into the explosive mixture.

I will first proceed to describe the mechanism of an engine in which the first of the above-mentioned ways of introducing the burning gases into the compressed air is applied, after which I will describe the operation of the said engine.

Upon the frame A are mounted two cylinders B C, which are preferably arranged in the same plane, the cylinder B being the power-cylinder and the cylinder C the air-compressing cylinder, and between the said cylinders is arranged the valve-chest D. In the cylinder B is placed the power-piston E, which is provided with a piston-rod *a*, passing out through a gland *b* in the front end of the cylinder. In the cylinder C is placed the air-compressing piston F, which is provided with a piston-rod *c*, passing out through a gland *d* in the front of the said cylinder. The piston-rod *a* of the power-cylinder is connected with the cross-head *e*, sliding in suitable guides upon the frame A, and the said cross-head is connected by a connecting-rod *f* with the crank *g* of the crank-shaft G. In a similar manner the piston-rod *c* of the air-compressing piston F is connected with the cross-head *h*, which slides in suitable guides upon the frame A, and the said cross-head is connected by a connecting-rod *i* with the crank *j* of the crank-shaft G.

In the valve-chest D there are two heating-chambers H H′, separated by the partition *k*, and between said chambers and the power-cylinder B there is a valve-chamber I, communicating with the chambers H H′. The valve-chamber I extends through the entire length of the cylinder B and communicates with opposite ends of the cylinder through ports *l l′*. It also communicates with the heating-chambers H H′ through ports *m m′*, which are opposite the ports *l l′*. At the middle of the length of the valve-chamber I there is an exhaust-opening *n* for the escape of the heated air and the products of combustion.

In the valve-chamber I is placed a D slide-valve J, of sufficient length to alternately establish communication between the ports *l l′* and the exhaust-opening *n*, and also to alternately establish communication between the heating-chambers H H′ and opposite ends of the power-cylinder B through the ports *l m l′ m′*. In Fig. 1 I have shown this valve in position to establish communication between the heating-chamber H and one end of the cylinder B through the ports *m l* and the chamber I, and also to bring the opposite end of the cylinder into communication with the exhaust-opening *n* through the port *l′* and the cavity of the valve J. The valve J is provided with a valve-rod *o*, which extends through a gland *p* at the front end of the valve-chest D and is connected with valve-operating mechanism, which will presently be described.

Upon the opposite side of the heating-chambers H H′ and between the said chambers and the air-compressing cylinder C is arranged a valve-chamber K, which contains the valves *q r*. In the side of the valve-chamber K adjoining the heating-chambers H H′, near the opposite ends of the said valve-chamber K, there are supply-ports *s s′* and ignition-ports *t t′* adjoining the partition *k*. In an enlargement of the partition *k* and between the ports *t t′* there is a cavity *u*, provided with a port *v*, and in which is arranged an igniting-burner *w*.

Between the valve-chamber K and the air-compressing cylinder C there is a thick partition-wall L, in which are formed ports a' a^2, which are opposite the ports *s s′*, and through which air may be forced into the heating-chambers H H′ when the ports b' c' b^2 c^2 of the valves *q r* are made to coincide with the ports a' *s* and a^2 *s′*, respectively.

The valve *q*, in addition to the ports b' b^2, near opposite ends thereof, is provided with cavities d' d^2 e' e^2 and ports f' f^2. It is also provided with right-angled passages g' g^2, which are oppositely arranged with respect to each other, and which establish communication between the cavities e' e^2 and the ports f' f^2 through burners h' h^2, arranged to discharge into the ports f' f^2. The said valve *q* is also provided with a valve-rod *i′*, which is operated in a manner presently to be described.

The valve *q* is offset at opposite ends to receive the valve *r*, which is arranged to embrace the offset portion of the valve *q*, and which is provided with a rod *j′*, operated in a manner also to be hereinafter described.

In the partition-wall L are formed ports k' k^2 near the ports a' a^2, the said ports k' k^2 communicating with the exterior air and being designed to supply air to the air-compressing cylinder C through the cavities d' d^2 of the valve *q* when the said valve is moved so as to bring one of the said cavities opposite the ports a' k' a^2 k^2. In Fig. 1 the cavity d^2 is shown in position to establish communication between the ports k^2 and a^2, so as to supply air to the cylinder C while the piston F moves in the direction indicated by the arrow.

Under the partition-wall L is placed a compression-cylinder M, containing a piston N, provided with a piston-rod l^2, which extends through a gland in the front of the cylinder and is operated by an eccentric m^2 on the crank-shaft G. The cylinder M communicates at opposite ends with ports o' o^2 in the wall L, and in the said wall are formed ports p' p^2, which are thrown into communication with the ports o' o^2 by the cavities e' e^2 in the valve q, and the said ports p' p^2 receive air through a circular row of holes q' and gas through a central hole r', the proportions of gas and air admitted through the said holes being such as to create an explosive mixture in the cylinder M, so that when the piston N of the cylinder M moves the mixture of gas and air is taken into the cylinder through the said openings and through the cavity of the valve q.

In the partition-wall L are formed chambers O O', in which the explosive mixture is compressed by the action of the piston N, as will be explained in the description of the operation of the machine. The said chambers O O' are provided with ports s^2 s^3, and between the said ports in the wall L is formed a cavity t^2, which communicates with the exhaust-opening u^2.

The valve-rod o is provided at its outer extremity with a fork a^3, in which is pivoted a block b^3, the said block being placed in a curved slot c^3 in one arm of the sector-lever Q. The other arm of the said lever is jointed to an eccentric-lever R, which is operated by the eccentric d^3 on the crank-shaft G. The valve-rod j' is jointed to an eccentric-rod e^3, which is operated by an eccentric f^3 on the crank-shaft G, and the valve-rod i' in a similar manner is jointed to a rod g^3, which is operated by an eccentric h^3 on the crank-shaft G.

The lost motion in the slot of the sector-lever Q admits of moving the valve J just as the piston E reaches the end of its stroke. As the same movement may be effected by means of a cam, I do not confine myself to this particular construction.

The operation of my improved gas-engine is as follows: Beginning the description of the cycle of operations with Fig. 1, I will assume that pressure is being exerted upon the piston E, forcing it in the direction indicated by the arrow; also, that the piston F of the air-compressor C is just beginning to move in the direction indicated by the arrow, and that the piston N of the mixture-pump is beginning to make a rearward movement, as indicated by the arrow. With the parts disposed in this manner, the valve J covers the port l' and establishes communication between the exhaust end of the cylinder and the exhaust-passage n, while the said valve J allows the heated mixture contained by the chamber H to escape through the ports m l into the cylinder B at the working side of the piston E. At the same moment, the ports a^2 k^2 being put into communication through the cavity d^2, air enters through the said ports into the cylinder C in front of the piston F, while communication between corresponding ports at the opposite end of the compressing-cylinder C is closed by the valve q and the compression of the air begins in the said cylinder C. At the same time, also, the port o^2 is put into communication with the port p^2 through the cavity e^2 in the valve q, thereby allowing the explosive mixture of gas and air to enter through the said ports into the mixture-compression cylinder M, and the charge previously drawn in and contained in the cylinder upon the opposite side of the piston N is being compressed and forced through the port o', cavity e', and port s^2 into the chamber O. At the same time the charge contained in the chamber O' is liberated by the coincidence of the port f^2 of the valve q with the ports s^3 t', and the explosive charge contained by the said chamber in its passage from the chamber O' to the chamber H' is ignited by the burner h^2 and exploded, so that the flame and heat resulting from the explosion enter from the port t' into the charge of compressed air previously introduced into the chamber H'. At this time the port f' in the valve q is brought into communication with the exhaust-passage t^2, also with the port v, and the explosive mixture is forced through the passage g' by the gas-compressor piston N into and through the burner h' into the port f', where it comes into contact with the igniting-flame of the burner w. The gas at the burner h' is ignited, and the flame is then supported by the mixture furnished through the passage g' until the valve q has gone so far back that the port f' stands opposite the port s^2 of the chamber O, when the flame ignites the charge compressed in the said chamber, the ignition of the charge occurring at the time when the power-piston is in its central position. The condition of the engine at this stage of the operation is as follows: The heated mixture contained by the chamber H has been expanded into the cylinder B and has pushed the piston E nearly to the limit of its forward stroke. The chamber H' contains air highly heated, also a quantity of the products of combustion of the charge of the chamber O', ready to be admitted to the front end of the cylinder B as soon as the valve J is shifted. As the piston E reaches the extreme forward limit of its stroke the valve J is shifted by the mechanism already described, so as to throw the rear end of the cylinder into communication with the exhaust-passage n through the port l and the cavity of the valve J, and at the same time to throw the chamber H' into communication with the forward end of the cylinder B through the ports m' l' in the manner shown in Fig. 2, and the piston E begins its return-stroke under the pressure of the heated air and gases contained by the chamber H'. At this time the piston F will have greatly reduced the volume of air in the cylinder C, and the ports b' c' of the valves q r will have coincided, and the said ports will have been brought into communication with the ports a' s, and the charge of air contained by the said cylinder will be forced into the chamber H. The piston N, also, in the cylinder M will have transferred most of the contents of the cylinder to the chamber O through the port o, cavity e' of the valve q, and the port s. By the further movement of the valve q the port f', in which the burner h' is burning, receives ignited gas and will be brought into communication with the chambers O H through the ports s^2 t, and the explosive mixture contained by the chamber O will be ignited and will force a jet of flame and hot gases through the port t into the body of air compressed by the chamber H, at which time communication will be closed between the compression-cylinder C and the chamber H by the valves q r, the relation of the said valves to each other being changed, so that the ports b' c' are closed, the position of the parts now being as shown in Fig. 3. The condition of the engine with the parts in this position is as follows: The products of combustion and the heated air have been driven out through the port l, cavity of the valve J, and the exhaust-passage n. The heated mixture contained by the chamber H' has been expanded into the cylinder B in front of the piston E, so as to force the said piston nearly to the rear end of its stroke, the pistons F N have reversed their motion and are beginning to take in new charges, and as the piston E reaches the extreme rear end of its stroke the valve J is quickly moved, so as to establish communication between the chamber H and the space in the cylinder B, behind the piston E, through ports l m, and at the same time to bring the forward end of the cylinder into communication with the exhaust-passage n through the port l' and cavity of the valve J, in the manner already described, when the piston E is forced forward by the pressure of the gases contained by the chambers H O.

It is obvious that the operations of compressing the air and gases, of igniting charges, and of exhausting are alike for both forward and rearward strokes of the piston E.

In the modification shown in Figs. 8 and 9 a thin wall L' is substituted for the thick wall L, the chambers O O' are dispensed with, and the valves q^3 r^3 are substituted for the valves q r. In other respects the engine is the same as that already described. The valve q^3 is provided with ports b^4, d^4, and e^4, and corresponding but oppositely-disposed ports b^5 d^5 e^5 at the other end, and the valve r^3 is provided with ports c^4 f^4 g^4 at one end and corresponding but oppositely-disposed ports c^5 f^5 g^5 at the other end. In this case the combustible mixture enters the compressed air contained in the chambers H H' through the ports t^2 t^3, gradually, in a state of flame. At the sides of the burner w are arranged valves i^4 i^5, attached to arms j^4 j^5, and each provided with an aperture k^5. The arms j^4 j^5 extend under the valves q^3 r^3 in a recess in the valve-casing and are each pressed upward by a spring l^4. On the valves q^3 r^3 are formed notches, one in each valve, into which the arms j^4 j^5 may enter, but only when these two notches coincide. When only one of the notches coincides with one of the said arms, the arm cannot move, as it will be retained by the other valve. In the sides of the chamber u are formed ports m^4 m^5, through which communication between the inflowing jet of combustible mixture and the flame of the burner w is established when the valves i^4 i^5 are opened in alternation.

In Fig. 1 the piston E is being driven forward by the expansion of the heated air and gas in the direction indicated by the arrow, while the combustible mixture is being forced into the chamber H' from the mixture-cylinder M by the piston N contained in the said cylinder, the mixture passing out through the port o^2 of the gas-compressor, the port e^5 in the valve q^3, through the port f^5, and through the burner h^4, located in the port t^3. The chamber H' having been previously filled with air under compression, and the combustible mixture having been ignited by the flame in the burner w, in the manner described, and all of the ports of the said chamber being closed, with the exception of the port t^3, the flame issuing from the burners in the said port heats the compressed air to a high temperature. While the piston N is moving forward, forcing the combustible mixture into the compressed air, it is drawing in through the port p^2, the port g^4 of the valve r^3, the port e^4 of the valve q^3, and the port o' a mixture of gas and air to be forced into the chamber H, after the said chamber is filled with compressed air, by the return of the piston F after the port m is closed and the ports a' s are opened. In type B the gas-inlets p' p^2 and the ports o' o^2 lie under the valves q^3 r^3.

The operation is the same for both ends of the cylinder. The difference between type B and A is, that in type B the combustible mixture flows gradually into the compressed air in an ignited state, whereas in the first instance the combustible mixture is ignited and at once enters the compressed air by an explosion, the entire heat being evolved instantaneously.

By some slight alterations of the valve arrangement and the positions of the respective pistons I might change the action of this engine in a certain degree.

One of the modifications I might make is to place the valve I and the power-piston E a quarter of a stroke forward, leaving all the other parts of the engine as shown. This would effect that the heating-chambers H H' would be thrown into communication with the power-cylinder B just after the air has been compressed and before it is heated. The explosive mixture would therefore flow into the compressed air and heat the same while the latter is moving the piston, while in the before-described case the compressed air is heated before it moves the piston. I remark here that this alteration does not affect in the slightest degree the principle of my invention, which remains the same in all above-described modifications as well as in engines types A and C, and which consists simply in compressing a charge of air or neutral gas into a closed chamber, and after the whole charge of air or neutral gas has been admitted into said chamber heating the said air or neutral gas by introducing into it an ignited explosive mixture and finally causing the compressed air or neutral gas and products of combustion to propel a piston.

In Fig. 14 I have shown a portion of an engine in which the separation of the air and explosive mixture is effected by a cylinder of two diameters and a corresponding piston of two diameters.

It will be seen that by the combustion of a small charge of explosive mixture and forcing the flame and heated gases of the said mixture into a body of compressed air I am enabled to strongly heat the air without bringing the flame into contact with the walls of the engine to any considerable extent, and therefore I am enabled to not only prolong the life of the engine, but also to avoid the use of cooling devices, and, further, I effect an enormous saving of fuel, as the heat is imparted directly to the charge of compressed air and communicated only in a small degree to the walls of the engine.

It is immaterial whether the ignition of the explosive mixture is effected by a flame-ignitor, as herein described, or by an electric spark, or whether the air is compressed in chambers, as described, or in the motor-cylinder. It is also immaterial whether the explosive mixture is introduced into the compressed air in a state of flame, while or before moving the piston, or whether the whole quantity of explosive mixture is introduced into the compressed air instantaneously by an explosion. For engines of type A it is also immaterial whether the explosive mixture is compressed. It is also immaterial whether the air is compressed by the motor-piston itself or by a separate air-compressing piston, or whether the air is first compressed in the compression-cylinder and then admitted to the chamber to be heated, or whether it is admitted during the entire stroke of the compression-piston.

I do not limit or confine myself in my present application to any particular kind of valve or any particular arrangement of the mechanism or of the chambers, or the gas and air inlets, as these and all other mechanical contrivances for carrying out my invention may be varied according to the particular use for which the engine is designed.

Having thus described my invention, I claim as new and desire to secure by Letters Patent—

1. The method of operating a gas-engine, which consists in compressing a certain charge of air or neutral gas into a heating-chamber, compressing a certain charge of explosive mixture, consisting of inflammable gas or vapor and air, igniting this explosive mixture, and causing it to enter in an ignited state into the said heating-chamber, in which the whole charge of compressed air or neutral gas is already contained, thereby heating the air or neutral gas, and finally discharging the heated compressed air or neutral gas and the products of combustion into a power-cylinder, causing them to move a piston, substantially as specified.

2. The method of heating a charge of compressed air or neutral gas by introducing the charge of compressed air or neutral gas into a heating-chamber and causing an ignited explosive mixture, consisting of inflammable gas or vapor and air, to enter into said heating-chamber, in which the whole charge of compressed air or neutral gas is alreadv contained, substantially as specified.

3. The method of preventing the dilution of the explosive mixture in a gas-engine, which consists in compressing a charge of air or neutral gas into a heating-chamber and introducing an ignited explosive mixture into said heating-chamber, in which the whole charge of compressed air or neutral gas is already contained, substantially as specified.

4. The method of operating a gas-engine, which consists in compressing a certain quantity of air or neutral gas into a heating-chamber or the motor-cylinder, introducing an explosive mixture into another chamber or the motor-cylinder, separated from the body of the compressed air or neutral gas by the motor-piston, establishing a communication between the compressed air or neutral gas and the explosive mixture by moving the motor-piston, in the meantime igniting the whole charge of said explosive mixture instantaneously, the exploding gases heating the body of the compressed air or neutral gas, and finally causing the so-heated compressed air or neutral gas and products of combustion to move a piston, substantially as specified.

5. The method of operating a gas-engine, which consists in compressing a certain quantity of air or neutral gas into a heating-chamber or the motor-cylinder, introducing an explosive mixture into a chamber separated from the body of the compressed air or neutral gas, igniting the whole charge of said explosive mixture instantaneously and causing the exploding gases to enter through automatic valves, or valves moved by the engine, into the body of the compressed air or neutral gas, thereby heating the same, and finally causing the so-heated compressed air or neutral gas and products of combustion to move a piston, substantially as specified.

6. The method of operating a gas-engine, which consists in compressing a certain quantity of air or neutral gas into a heating-chamber, causing a compressed charge of explosive mixture to flow in a state of flame gradually into the chamber in which the whole charge of compressed air or neutral gas is contained, then heating the body of compressed air or neutral gas, the quantity of which latter being constant and not augmented while being heated, except by the

products of combustion of the explosive mixture, and, finally, after the complete combustion of the explosive charge, discharging the heated compressed air or neutral gas and products of combustion into a power-cylinder, causing it to move a piston, substantially as specified.

7. The method of operating a gas-engine, which consists in compressing a certain quantity of air or neutral gas into a heating-chamber or the motor-cylinder, causing a compressed charge of explosive mixture to flow in a jet gradually into the chamber or motor-cylinder in which the whole charge of air or neutral gas is contained, said jet of explosive mixture being ignited when flowing into and thus heating the body of the compressed air or neutral gas, the quantity of which latter being constant and not augmented while being heated, except by the products of combustion of the explosive mixture, the compressed air or neutral gas and products of combustion being caused to move a piston, while the explosive mixture flows into the compressed air or neutral gas and heats the same, substantially as specified.

8. The method of using heating-chambers communicating with the motor-cylinder by suitable valves, into which heating-chambers charges of compressed air or neutral gas and charges of an ignited explosive mixture are introduced intermittingly and successively to each other, each charge of air being first admitted and then being heated by a charge of an ignited explosive mixture, the so-heated air or neutral gas and the products of combustion then being discharged into the power-cylinder to move a piston, substantially as specified.

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Witnesses:
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